Amendments to the Claims

Please amend the claims to read as follows.

1. (Previously Presented): A system for interactively displaying three dimensional structures comprising:

a. volume formation means for forming a three-dimensional volume of data from a series of two-dimensional images representing at least one physical property associated with a three dimensional body;

b. segmentation means for segmenting a region of interest from the volume of data based on selected values of the physical property representing the region of interest;

c. means for producing a wireframe model of the segmented region of interest, the wireframe model comprising a plurality of vertices, each vertex having a coordinate position;

d. means for refining the wireframe model by adjusting the coordinate positions of the vertices to more accurately represent the region of interest; and

e. rendering means for rendering the wireframe model in an interactive three-dimensional display, therein producing a virtual three-dimensional environment,

wherein the segmentation means approximates the region of interest and the refinement means adjusts the coordinate positions of the vertices along a normal vector associated with each vertex.

2 . (Canceled)

3. (Previously Presented): The system of Claim 1 wherein the refinement means adjusts the coordinate positions of the vertices along a normal vector associated with each vertex as a function of a surface curvature at the coordinate position.

4. (Previously Presented): The system of Claim 1 wherein the refinement means adjusts the coordinate positions of the vertices along a normal vector associated with each vertex by determining an inner wall position and an outer wall position from a first and a second degree derivative associated with the coordinate positions of the vertices.

5. (Original) The system of Claim 1 wherein the segmentation means, the wireframe producing means, and the refining means are located remotely from the volume formation means.

6 . (Previously Presented): A system for interactively displaying three dimensional structures comprising:

a. volume formation means for forming a three-dimensional volume of data from a series of two-dimensional images representing at least one physical property associated with a three dimensional body;

b. segmentation means for segmenting a region of interest from the volume of data based on selected values of the physical property representing the region of interest;

c. isosurface creation means for creating an isosurface of the segmented region of interest;

d. model means for producing a wireframe model of the segmented region of interest; and

e. rendering means for rendering the wireframe model in an interactive three-dimensional display, therein producing a virtual three dimensional environment,

wherein the isosurface creation means comprises means for identifying a seed voxel from the segmented region of interest and means for producing an isosurface patch associated with the seed voxel.

7. (Canceled)

8. (Original) The system of Claim 6 wherein the segmentation means, the isosurface creation means, and the wireframe producing means are located remotely from the volume formation means.

9. (Original) A system for interactively displaying a three-dimensional rendering of a structure having a lumen and indicating regions having abnormal structure comprising:

a. volume formation means for forming a three-dimensional volume of data from a series of two-dimensional images representing at least one physical property associated with the three-dimensional structure;

b. segmentation means for segmenting a region of interest from the volume of data based on a selected value of the physical property representing the region of interest;

c. wireframe generation means for generating a wireframe model of the segmented region of interest;

d. vertex grouping means for grouping the vertices of the wireframe model into regions having abnormal structure;

e. analyzing means for analyzing the regions having abnormal structure; and

f. rendering means for rendering the wireframe model in an interactive three-dimensional display to indicate the regions having abnormal structure.

10. (Original) The system of Claim 9 wherein the analyzing means comprises means for evaluating two principal curvatures associated with each point in an elliptical region.

11. (Original) The system of Claim 10 wherein the analyzing means comprises a means for identifying ridges.

12. (Original) The system of Claim 10 wherein the segmentation means, the wireframe generating means, the vertex grouping means, and the analyzing means are located remotely from the volume formation means.

13. (Original) A computer-implemented method for interactively displaying a three-dimensional rendering of a structure having a lumen and indicating regions having abnormal structure comprising the steps of:

a. forming a three-dimensional volume of data from a series of two-dimensional images representing at least one physical property associated with the three-dimensional structure;

b. segmenting a region of interest from the volume of data based on a selected value of the physical property representing the region of interest;

c. generating a wireframe model of the segmented region of interest, the wireframe model comprising a plurality of vertices, each vertex having a coordinate position;

d. grouping the vertices of the wireframe model into regions having a characteristic indicating abnormal structure;

e. analyzing the regions having abnormal structure to identify regions having a high degree of abnormality; and

f. rendering the wireframe model in an interactive three-dimensional display to indicate the regions having abnormal structure.

14. (Original) The method of Claim 13 wherein the segmentation step comprises the steps of:

a. selecting a voxel near a surface of interest;

b. identifying a seed voxel from the selected voxel;

c. inserting the seed voxel into an adjacency tree;

d. producing a surface patch associated with the seed voxel;

e. inserting all unexamined voxels in the surface patch into a seed voxel queue;

f. removing a seed voxel from the seed voxel queue; and

g. repeating step 14.c through step 14.f until the seed voxel queue is empty.

15. (Original) The method of Claim 13 wherein the segmentation step, the wireframe generating step, the grouping step, and the analyzing step are performed remotely from the volume formation step.

16-22. (Canceled)

23. (Previously Presented): A method for guiding biopsy of a tissue by accessing the tissue via a three-dimensional structure having a lumen comprising the steps of:

a. forming a three-dimensional volume of data from a series of two-dimensional images representing at least one physical property associated with the three-dimensional structure and at least one physical property associated with the tissue;

b. segmenting a first region of interest from the volume of data based on a selected value of the physical property associated with the three-dimensional structure;

c. creating a first surface of the first region of interest;

d. generating a first wireframe model of the surface of the first region of interest;

e. segmenting a second region of interest from the volume of data based on a selected value of the physical property associated with the tissue;

f. creating a second surface of the second region of interest;

g. generating a second wireframe model of the isosurface of the second region of interest;

h. rendering the first and second wireframe models in an interactive three-dimensional environment;

i. inserting a simulated biopsy needle within the lumen of the three-dimensional structure;

j. determining the position of the simulated biopsy needle within the three-dimensional structure;

k. displaying the rendered, interactive three-dimensional display from a perspective indicating the position of the biopsy needle within the three-dimensional structure; and

l. generating a zone around the simulated tissue and issuing an indicator when the tip of the simulated biopsy needle is within the zone.

24. (Original) The method of Claim 23 comprising the step of indicating the position of the simulated biopsy needle relative to the position of the tissue.

25. (Canceled)

26. (Original) The method of Claim 24 wherein the indicating step comprises the step of determining a distance and a trajectory from the simulated biopsy needle to the simulated tissue.

27. (Original) The method of Claim 13, 16, or 18 comprising an image acquisition step wherein a series of two-dimensional images representing at least one physical property associated with the structure is acquired, wherein the image acquisition step comprises a patient preparation step.

28. (Original) The method of Claim 27 wherein the patient preparation step comprises the step of administering to a patient a nonionic intravenous iodinated contrast bolus.

29. (Original) The method of Claim 27 wherein the patient preparation step comprises the step of administering to a patient an oral contrast agent for opacifying stool and water.

30. (Previously Presented): A system for interactively displaying three dimensional structures comprising:

a. volume formation means for forming a three-dimensional volume of data from a series of two-dimensional images representing at least one physical property associated with a three-dimensional body;

b. modeling means for producing a wireframe model of a selected region of interest, the wireframe model comprising a plurality of vertices, each vertex having a coordinate position;

c. refinement means for refining the wireframe model by adjusting the coordinate positions of the vertices to more accurately represent the region of interest; and

d. rendering means for rendering the wireframe model in an interactive three-dimensional display, therein producing a virtual three-dimensional environment,

wherein the refinement means adjusts the coordinate positions of vertices of the wireframe model along a normal vector associated with each vertex at a rate that is a function of a surface curvature at the coordinate position.

31. (Canceled).

32. (Currently Amended): The system of Claim 32 wherein the refinement means adjusts the coordinate positions of the vertices along a normal vector associated with each vertex by determining an inner wall position and an outer wall position from an analysis of intensity profiles of voxel values along the normal vector.

33. (Original) The system of Claim 30 wherein the modeling means, and the refining means are located remotely from the volume formation means.

34. (Previously Presented): A system for interactively displaying three dimensional structures comprising:

a. volume formation means for forming a three-dimensional volume of data from a series of two-dimensional images representing at least one physical property associated with a three dimensional body;

b. wireframe producing means for producing a wireframe model of a selected region of interest of the three-dimensional volume;

c. deforming means for deforming the wireframe model using a geometric deformable model to more accurately represent the region of interest; and

d. rendering means for rendering the wireframe model in an interactive three-dimensional display, therein producing a virtual three-dimensional environment.

35 . (Original) A system for interactively displaying a three-dimensional rendering of a structure having a lumen and indicating regions having abnormal structure comprising:

a. volume formation means for forming a three-dimensional volume of data from a series of two-dimensional images representing at least one physical property associated with the three-dimensional structure;

b. wireframe generation means for generating a wireframe model of a selected region of interest;

c. vertex grouping means for grouping the vertices of the wireframe model into regions having abnormal structure;

d. analyzing means for analyzing the regions having abnormal structure; and

e. rendering means for rendering the wireframe model in an interactive three-dimensional display to indicate the regions having abnormal structure.

36 . (Original) The system of Claim 35 wherein the analyzing means comprises means for evaluating two principal curvatures associated with each point in an elliptical region.

37. (Original) The system of Claim 36 wherein the analyzing means comprises a means for identifying ridges.

38. (Original) The system of claim 37 comprising wireframe deforming means for deforming the wireframe model to more accurately represent the region of interest.

39. (Original) A computer-implemented method for interactively displaying a three-dimensional rendering of a structure having a lumen and indicating regions having abnormal structure comprising the steps of:

a. forming a three-dimensional volume of data from a series of two-dimensional images representing at least one physical property associated with the three-dimensional structure;

b. generating a wireframe model of a selected region of interest, the wireframe model comprising a plurality of vertices, each vertex having a coordinate position;

c. grouping the vertices of the wireframe model into regions having a characteristic indicating abnormal structure; and

d. analyzing the regions having abnormal structure to identify regions having a high degree of abnormality.

40. (Original) The method of claim 39 comprising the steps of rendering the wireframe model in an interactive three-dimensional display to indicate the regions having abnormal structure.

41. (Previously Presented): A computer-implemented method for interactively displaying a three-dimensional rendering of a structure having a lumen comprising the steps of:

a. forming a three-dimensional volume of data from a series of two-dimensional images representing at least one physical property associated with the three-dimensional structure;

b. generating a wireframe model of a selected region of interest;

c. deforming the wireframe model using a geometric deformable model to more accurately represent the region of interest; and

d. rendering the wireframe model in an interactive three-dimensional display.

42. (Previously Presented): A computer-implemented method for interactively displaying a three-dimensional rendering of a structure having a lumen comprising the steps of:

a. forming a three-dimensional volume of data from a series of two-dimensional images representing at least one physical property associated with the three-dimensional structure;

b. generating a wireframe model of a selected area of interest;

c. refining the wireframe model of the selected region of interest to more accurately represent the region of interest; and

d. rendering the wireframe model in an interactive three-dimensional display,

wherein the refinement step adjusts coordinate positions of vertices of the wireframe model along a normal vector associated with each vertex at a rate that is a function of a surface curvature at the coordinate position.

43. (Canceled)

44. (Previously Presented): The method of Claim 42 wherein the refinement step adjusts the coordinate positions of the vertices along a normal vector associated with each vertex by determining an inner wall position and an outer wall position from a first and a second degree derivative associated with the coordinate positions of the vertices.

45. (Original) A method for guiding biopsy of a tissue by accessing the tissue via a three-dimensional structure having a lumen comprising the steps of:

a. forming a three-dimensional volume of data from a series of two-dimensional images representing at least one physical property associated with the three-dimensional structure and at least one physical property associated with the tissue;

b. generating a wireframe model of a selected region of interest;

c. rendering the wireframe model in an interactive three-dimensional display;

d. inserting a simulated biopsy needle within the lumen of the three-dimensional structure;

e. determining the position of the simulated biopsy needle within the three-dimensional structure;

f. displaying the rendered, interactive three-dimensional display from a perspective indicating the position of the simulated biopsy needle within the three-dimensional structure;

g. generating a zone around the tissue and issuing an indicator when a tip of the biopsy needle is within the zone.

46. (Original) The method of Claim 45 comprising the step of indicating the position of the simulated biopsy needle relative to the position of the tissue.

47. (Canceled)

48. (Original) The method of Claim 46 wherein the indicating step comprises the step of determining a distance and a trajectory from the simulated biopsy needle to the tissue.

49. (Original) The method of Claim 39, 41, 42, or 45 comprising an image acquisition step wherein a series of two-dimensional images representing at least one physical property associated with the structure is acquired, wherein the image acquisition step comprises a patient preparation step.

50. (Original) The method of Claim 49 wherein the patient preparation step comprises the step of administering to a patient a nonionic intravenous iodinated contrast bolus.

51. (Original) The method of Claim 49 wherein the patient preparation step comprises the step of administering to a patient an oral contrast agent for opacifying stool and water.

52. (Previously Presented): A method for guiding biopsy of a tissue by accessing the tissue via a three-dimensional structure having a lumen comprising the steps of:

a. providing a three-dimensional volume of data representing at least one physical property associated with the three-dimensional structure;

b. isolating a first region of interest of the structure having the lumen;

c. rendering the first region of interest in an interactive three-dimensional display;

d. inserting a simulated biopsy needle within the lumen of the rendered first region of interest;

e. determining the position of the simulated biopsy needle within the rendered first region of interest having the lumen;

f. displaying the simulated biopsy needle within the rendered first region of interest having the lumen;

g. determining the position of the needle relative to a selected target zone;

h. generating a ready-to-strike indicator if the needle is within a desired location relative to the selected target zone; and

i. calculating a movement pathway for the needle to strike the target zone if the needle is not within a desired location relative to the selected target zone.

53. (Original) The method of claim 52 comprising the step of isolating the first region of interest from the volume of data based on a selected value of the physical property associated with the three-dimensional structure.

54. (Original) The method of claim 53 wherein the step of isolating the first region of interest comprises segmenting the first region of interest.

55. (Original) The method of any one of claims 52 - 54 comprising:

providing a three-dimensional volume of data representing at least one physical property associated with the tissue;

isolating a second region of interest of the structure having the tissue;

rendering the second region of interest in the interactive three-dimensional display; and

creating at least one target zone of needle placement at a selected site of the rendered tissue.

56. (Original) The method of claim 55 comprising the step of isolating the second region of interest from the volume of data based on a selected value of the physical property associated with the tissue.

57. (Original) The method of claim 56 wherein the step of isolating the second region of interest comprises segmenting the second region of interest.

58. (Canceled)

59. (Original) The method of claim 52 comprising:

providing a three-dimensional volume of data representing at least one physical property associated with mediastinal tissue;

isolating a second region of interest of the structure having the mediastinal tissue;

rendering the second region of interest in the interactive three-dimensional display; and

positioning the needle so as to avoid the rendered mediastinal tissue.

60. (Previously Presented): A system for interactively displaying three dimensional structures comprising:

a. volume formation means for forming a three-dimensional volume of data representing at least one physical property associated with a three dimensional structure;

b. a wireframe generator for generating a wireframe model having vertices of a region of interest representing the three-dimensional structure;

c. refinement means for refining the wireframe model by using a geometric deformable model;

d. a renderer for rendering the wireframe model in an interactive three-dimensional display;

e. a vertex grouper for grouping the vertices of the wireframe model into regions having abnormal structure; and

f. an analyzer for analyzing the regions having abnormal structure.

61. (Original) The system of claim 60 wherein the renderer produces a virtual three-dimensional environment.

62. (Original) The system of claim 60 comprising an isolator for isolating the region of interest from the volume of data based on selected values of the physical property representing the region of interest.

63. (Original) The system of claim 62 wherein the renderer produces a virtual three-dimensional environment.

64. (Original) The system of claim 62 wherein the isolator comprises a surface model identification means for identifying a surface model and wherein the wireframe generator is adapted to create a wireframe model of the surface model.

65. (Original) The system of claim 62 wherein the isolator comprises a segmentation producer for segmenting the region of interest from the volume of data.

66. (Original) The system of claim 65 wherein the isolator comprises an isosurface creation means for creating an isosurface of the isolated region of interest.

67. (Original) The system of claim 66 wherein the wireframe generator is adapted to create a wireframe model of the isosurface.

68. (Canceled)

69. (Original) The system of claim 60 wherein the vertex grouper comprises:

a. a mean curvature calculator for calculating a mean curvature at each of a selected number of vertices;

b. a gaussian curvature calculator for calculating a gaussian curvature at each of the selected number of vertices; and

c. classification means for classifying the selected vertices according to the mean curvatures and the gaussian curvatures of the vertices.

70. (Original) A computer-implemented method for interactively displaying a three-dimensional rendering of a structure having a lumen comprising the steps of:

a. providing a three-dimensional volume of data representing at least one physical property associated with the structure having the lumen;

b. generating a wireframe model having vertices representing a region of interest of the structure having the lumen;

c. refining the wireframe model using a geometric deformable model; and

d. rendering the wireframe model in an interactive three-dimensional display.

7 1. (Original) The method of claim 70 wherein the wireframe model comprises a plurality of vertices, the method comprising:

grouping the vertices of the wireframe model into regions having a characteristic indicating abnormal structure;

analyzing the regions having abnormal structure to identify regions having a high degree of abnormality; and

rendering the wireframe model in an interactive three-dimensional display to indicate the regions having abnormal structure.

72. (Original) The method of claim 71 wherein the grouping step comprises:

calculating a mean curvature at selected vertices;

calculating a gaussian curvature at the selected vertices;

classifying the selected vertices according to the mean curvature and the gaussian curvature; and

grouping adjoining selected vertices into patches of same vertex classification.

73. (Original) The method of claim 72 wherein the analyzing step comprises labeling patches having an elliptical classification as a potential lesion.

74. (Original) The method of claim 73 wherein the analyzing step comprises eliminating from the grouping selected elliptical patches which point outwardly from the lumen.

75. (Original) The method of claim 74 wherein the analyzing step comprises calculating principal curvatures of the patches from the mean and gaussian curvatures and eliminating from the grouping any elliptical patches having substantially different principal curvatures.

76. (Original) The method of claim 70 comprising calculating a normal vector for each vertex in the wireframe model.

77. (Original) The method of claim 76 wherein the refinement step comprises moving each vertex of the wireframe model along its normal vector direction at a speed that is a function of a surface curvature and a doubt level of a boundary estimate at that point.

78. (Original) The method of claim 76 wherein the refinement step uses a three-dimensional region growing model as a starting point for the geometric deformable model.

79. (Original) The method of claim 78 wherein the refinement step uses a three-dimensional region growing model as a starting point for the geometric deformable model.

80. (Original) The method of claim 70 wherein the step of generating a wireframe model comprises the steps of identifying a surface model of the region of interest and generating a wireframe model of the surface model.

81. (Original) The method of claim 80 comprising:

grouping the vertices of the wireframe model into regions having a characteristic indicating abnormal structure;

analyzing the regions having abnormal structure to identify regions having a high degree of abnormality; and

rendering the wireframe model in an interactive three-dimensional display to indicate the regions having abnormal structure.

82. (Original) The method of claim 81 wherein the grouping step comprises:

calculating a mean curvature at selected vertices;

calculating a gaussian curvature at the selected vertices;

classifying the selected vertices according to the mean curvature and the gaussian curvature; and

grouping adjoining selected vertices into patches of same vertex classification.

83. (Original) The method of claim 82 wherein the analyzing step comprises labeling patches having an elliptical classification as a potential lesion.

84. (Original) The method of claim 83 wherein the analyzing step comprises eliminating from the grouping selected elliptical patches which point outwardly from the lumen.

85. (Original) The method of claim 84 wherein the analyzing step comprises calculating principal curvatures of the patches from the mean and gaussian curvatures and eliminating from the grouping any elliptical patches having substantially different principal curvatures.

86. (Original) The method of claim 70 comprising isolating the region of interest from the volume of data based on a selected value of the physical property representing the region of interest.

87. (Original) The method of claim 86 wherein the step of isolating comprises segmenting the region of interest.

88. (Original) The method of claim 87 comprising creating an isosurface of the region of interest.

89. (Original) The method of claim 88 wherein the step of generating a wireframe model comprises generating a wireframe model of the isosurface.

90. (Original) The method of claim 89 wherein, the wireframe model comprises a plurality of vertices, the method comprising:

grouping the vertices of the wireframe model into regions having a characteristic indicating abnormal structure;

analyzing the regions having abnormal structure to identify regions having a high degree of abnormality; and

rendering the wireframe model in an interactive three-dimensional display to indicate the regions having abnormal structure.

91. (Original) The method of claim 90 wherein the grouping step comprises:

calculating a mean curvature at selected vertices;

calculating a gaussian curvature at the selected vertices;

classifying the selected vertices according to the mean curvature and the gaussian curvature; and

grouping adjoining selected vertices into patches of same vertex classification.

92. (Original) The method of claim 91 wherein the analyzing step comprises labeling patches having an elliptical classification as a potential lesion.

93. (Original) The method of claim 92 wherein the analyzing step comprises eliminating from the grouping selected elliptical patches which point outwardly from the lumen.

94. (Original) The method of claim 93 wherein the analyzing step comprises calculating principal curvatures of the patches from the mean and gaussian curvatures and eliminating from the grouping any elliptical patches having substantially different principal curvatures.

95. (Original) A computer-implemented method for interactively displaying a three-dimensional rendering of a structure having a lumen comprising the steps of:

a. providing a three-dimensional volume of data representing at least one physical property associated with the structure having the lumen;

b. generating a wireframe model having a plurality of vertices to represent the structure having the lumen;

c. grouping the vertices by:

calculating a mean curvature at each of a selected number of vertices,

calculating a gaussian curvature at each of the selected number of vertices,

classifying the selected vertices according to the mean curvatures and

the gaussian curvatures of the vertices, and

collecting adjoining vertices of similar classification into patches of similar vertex classification; and

d. rendering the wireframe model in an interactive three-dimensional display.

96. (Original) The method of claim 95 comprising isolating a region of interest from the volume of data based on a selected value of the physical property representing the region of interest.

97. (Original) The method of claim 96 wherein the step of isolating comprises segmenting the region of interest.

98. (Original) The method of claim 95 wherein the step of generating a wireframe model comprises the steps of identifying a surface model of the region of interest and generating a wireframe model of the surface model.

99. (Original) The method of claim 95 comprising creating an isosurface of the region of interest.

100. (Original) The method of claim 95 comprising labeling patches having an elliptical classification as a potential lesion.

101. (Original) The method of claim 100 comprising eliminating from the grouping selected elliptical patches which point outwardly from the lumen.

102. (Original) The method of claim 101 comprising calculating principal curvatures of the patches from the mean and gaussian curvatures and eliminating from the grouping any elliptical patches having substantially different principal curvatures.

103. (Original) A system for interactively displaying three dimensional structures comprising:

a. volume formation means for forming a three-dimensional volume of data representing at least one physical property associated with a three dimensional structure;

b. a wireframe generator for generating a wireframe model having a plurality of vertices to represent a region of interest of the three-dimensional structure;

c. a vertex grouper for collecting adjoining vertices having similar classifications based on mean and gaussian curvatures into patches of similar vertex classification; and

d. a renderer for rendering the wireframe model in an interactive three-dimensional display.

104. (Original) The system of claim 103 wherein the renderer produces a virtual three-dimensional environment.

105. (Original) The system of claim 103 comprising an isolator for isolating the region of interest from the volume of data based on selected values of the physical property representing the region of interest.

106. (Original) The system of claim 105 wherein the renderer produces a virtual three-dimensional environment.

107. (Original) The system of claims 105 or 106 wherein the isolator comprises a segmentation producer for segmenting the region of interest from the volume of data.

108. (Original) The system of claim 105 wherein the isolator comprises a surface model identification means for identifying a surface model and wherein the wireframe generator is adapted to create a wireframe model of the surface model.

109. (Original) The system of claim 105 wherein the isolator comprises an isosurface creation means for creating an isosurface of the isolated region of interest.

110. (Original) The system of claim 103 wherein the vertex grouper comprises:

a mean curvature calculator for calculating a mean curvature at each of a selected number of vertices;

a gaussian curvature calculator for calculating a gaussian curvature at each of the selected number of vertices; and

classification means for classifying the selected vertices according to the mean curvatures and the gaussian curvatures of the vertices.

111. (New) The method of claim 13 wherein the step of analyzing comprises evaluating two principal curvatures associated with each point in an elliptical region.